

CLAIMS

1. A semiconductor device comprising:

(a) a first semiconductor region having a first conductivity type formed over a semiconductor substrate;

(b) a first insulation film deposited over said semiconductor substrate;

(c) an opening portion opened in said first insulation film;

(d) a first semiconductor film having a second conductivity type that is a conductivity type opposite to said first conductivity type, provided over said first insulation film, and extending so that a portion thereof is protruded from an end of said opening portion toward a center of the opening portion;

(e) a second semiconductor film having the second conductivity type formed toward a main surface of said semiconductor substrate with a surface of a protruded portion of said first semiconductor film contacting with a surface opposite to said semiconductor substrate;

(f) a third semiconductor film having the second conductivity type formed so as to contact with the main surface of said semiconductor substrate and said second semiconductor film; and

(g) a second insulation film formed over said first semiconductor film and a side surface of said first semiconductor film located over said opening portion,

(h) wherein, of said second insulation film formed over the side surface of said first semiconductor film, length of a portion extending so as to protrude from a bottom surface of said first semiconductor film toward the main surface of said semiconductor substrate is equal to or smaller than one half of thickness of said first insulation film in a direction intersecting with said semiconductor substrate.

2. The semiconductor device according to claim 1 wherein a fourth semiconductor film has the first conductivity type so as to be electrically connected to said third semiconductor film and insulated from said first semiconductor film.

3. The semiconductor device according to claim 1, wherein the second insulation film formed over the side surface of said first semiconductor film is protruded upward from an upper surface of the second insulation film over said first semiconductor film.

4. The semiconductor device according to claim 1, wherein said second semiconductor film is made from a silicon nitride film.

5. The semiconductor device according to claim 1, wherein said second semiconductor film is made from a

poly crystal.

6. The semiconductor device according to claim 1,
wherein said third semiconductor film is made from a
single crystal.

7. The semiconductor device according to claim 1,
wherein said second and third semiconductor films are
each made from a material primarily containing silicon-
germanium.

8. A semiconductor device comprising:

(a) a first semiconductor region of a first
conductivity type formed over a semiconductor substrate;

(b) a first insulation film deposited over said
semiconductor substrate;

(c) an opening portion opened in said first insulation
film;

(d) a first electrode of a second conductivity type
that is a conductivity type opposite to said first
conductivity type, located over said first insulation film,
and extending so that a portion thereof is protruded from
an end of said opening portion toward a center of the
opening portion;

(e) a third semiconductor film located over said first
electrode;

(f) a semiconductor film provided in said opening

portion, electrically connected through a protruded portion of said first electrode, and electrically connected to said first semiconductor region; and

(g) a fourth insulation film provided over a first surface intersecting with a main surface of said semiconductor substrate in a surface of a protruded portion of said first electrode, extending so as to protrude toward the main surface of said semiconductor substrate from a second surface opposite to said semiconductor substrate in the surface of said protruded portion of said first electrode, and provided so that length of the protruded portion is equal to or smaller than one half of thickness of said first insulation film.

9. The semiconductor device according to claim 8, wherein a second electrode of the first conductivity type is provided so as to be electrically connected to said semiconductor film and insulated from said first electrode.

10. The semiconductor device according to claim 8, wherein said fourth insulation film is a surface of a protruded portion of said third insulation film located over the protruded portion of said first electrode, the surface being provided so as to overlap with a third surface intersecting with the main surface of said semiconductor substrate.

11. The semiconductor device according to claim 10,
wherein a portion of said fourth insulation film
protrudes from an upper surface of said third insulation
film.
12. The semiconductor device according to claim 8,
wherein said third and fourth insulation films are
insulation films of the same kind and are insulation films
of a kind different from said first insulation film.
13. The semiconductor device according to claim 8,
wherein said third and fourth insulation films are
made from silicon nitride films.
14. The semiconductor device according to claim 8,
wherein said semiconductor film is made from a
material containing primarily a semiconductor of a kind
different from said semiconductor substrate.
15. The semiconductor device according to claim 14,
wherein said semiconductor film is made from a
material containing primarily silicon-germanium.
16. The semiconductor device according to claim 8,
wherein said semiconductor film has a second
semiconductor film growing from said second surface of said
first electrode, and a third semiconductor film growing

from the main surface of said semiconductor substrate so as to be connected to the second semiconductor film.

17. The semiconductor device according to claim 16,

wherein said second semiconductor film is made from a poly crystal and said third semiconductor film is made from a single crystal.

18. A semiconductor device having a bipolar transistor, comprising:

(a) a first semiconductor region which is a collector region of said bipolar transistor and is of a first conductivity type formed over said semiconductor substrate;

(b) a silicon oxide film deposited over said semiconductor substrate;

(c) an opening portion opened in said silicon oxide film;

(d) a first polycrystalline silicon film provided over said silicon oxide film, having a second conductivity type which is a conductivity type opposite to said first conductivity type, and extending so that a portion thereof is protruded from an end portion of said opening portion toward a center of said opening portion;

(e) a polycrystalline silicon-germanium film of the second conductivity type, which is formed toward a main surface of said semiconductor substrate with a surface of a protruded portion of said first polycrystalline silicon

film contacting with a surface opposite to said semiconductor substrate;

(f) a single crystalline silicon-germanium film of the second conductivity type, which is formed so as to contact with the main surface of said semiconductor and said polycrystalline silicon-germanium film;

(g) silicon nitride films formed over said first polycrystalline silicon film and a side surface of said first polycrystalline silicon film located over said opening portion,

Wherein, of the silicon nitride film formed over the side surface of said first polycrystalline silicon film, length of a portion extending so as to protrude from a bottom surface of said first polycrystalline silicon film toward the main surface of said semiconductor substrate is equal to or smaller than one half of thickness of said silicon oxide film in a direction intersecting with said semiconductor substrate, and said silicon nitride film formed over the side surface of said first polycrystalline silicon film protrudes upward from an upper surface of said silicon nitride film over said first polycrystalline silicon film.

19. A semiconductor device having a bipolar transistor, comprising:

(a) a collector region of a first conductivity type formed over said semiconductor substrate;

(b) a first insulation film deposited over said semiconductor substrate;

(c) an opening portion opened in said first insulation film;

(d) a base electrode having a second conductivity type that is a conductivity type opposite to said first conductivity type, provided over said first insulation film, and formed so that a portion thereof extends and protrudes from an end portion of said opening portion toward a center of said opening portion;

(e) a third semiconductor film provided over said base electrode;

(f) a semiconductor film formed with said base electrode and said corrector region in said opening portion contacting with each other;

(g) a base region of the second conductivity type, which is formed over said semiconductor film and electrically connected through a protruded portion of said base electrode;

(h) an emitter region of the first conductivity type, which is formed in said base region of said semiconductor film; and

(i) an emitter electrode of the first conductivity type, which is electrically connected to said emitter region and insulated from said base electrode; and

(j) a fourth insulation film provided over a first surface which is a surface of the protruded portion of said

base electrode and intersects with a main surface of said semiconductor substrate, wherein the fourth insulation film is provided so that length of a portion, which extends so as to protrude toward a main surface of said semiconductor substrate from a second surface that is a surface of the protruded portion of said base electrode and is opposite to said semiconductor substrate, is equal to or smaller than one half of thickness of said first insulation film.

20. The semiconductor device according to claim 19,

wherein said fourth insulation film is provided so as to overlap with a third surface that is a surface of said third insulation film over a protruded portion of said base electrode and intersects with the main surface of said semiconductor substrate.

21. The semiconductor device according to claim 19,

wherein a portion of said fourth insulation film protrudes from an upper surface of said third insulation film.

22. The semiconductor device according to claim 19,

wherein said third and fourth insulation films are insulation films of the same kind and are insulation films of a kind different from said first insulation film.

23. The semiconductor device according to claim 19,

wherein said third and fourth insulation films are made from silicon nitride films.

24. The semiconductor device according to claim 19, wherein said semiconductor film is made from a material containing primarily a semiconductor of a kind different from said semiconductor substrate.

25. The semiconductor device according to claim 19, wherein said semiconductor film is made from a material containing primarily silicon-germanium.

26. The semiconductor device according to claim 19, wherein said semiconductor film has a second semiconductor film growing from said second surface of said base electrode and a third semiconductor film growing from the main surface of said semiconductor substrate so as to be connected to the second semiconductor film.

27. The semiconductor device according to claim 26, wherein said second semiconductor film is made from a poly crystal and said third semiconductor film is made from a single crystal.

28. A manufacturing method for a semiconductor device, comprising the steps of:

(a) forming a first semiconductor region of a first

conductivity type over a semiconductor substrate;

(b) depositing a first insulation film over a main surface of said semiconductor substrate;

(c) depositing a first semiconductor film of a second conductivity type opposite to said first conductivity type over said first insulation film;

(d) depositing a third insulation film of a kind different from said first insulation film over said first semiconductor film;

(e) depositing a fifth insulation film capable of taking an etching selective ratio to said third insulation film over said third insulation film;

(f) opening portions of said fifth insulation film and third insulation film by an etching method using a photoresist film as an etching mask;

(g) removing said photoresist film, and thereafter removing said first semiconductor film exposed from the opening by using said fifth insulation film as an etching mask to form a first opening portion in said third and fifth insulation films and said first semiconductor film;

(h) forming a sixth insulation film of a kind different from said first insulation film over a side surface of said first opening portion;

(i) forming, over said first insulation film, a second opening portion in which a surface opposite to the main surface of said semiconductor substrate and said first semiconductor region in said first semiconductor film are

exposed, by selectively etching a portion of said first insulation film through said first opening portion using said third insulation film and sixth insulation film as etching masks; and

(j) forming a semiconductor film in said second opening portion,

Wherein, during a processing for forming said first opening portion, an amount in which a portion of said first insulation film exposed from said first opening portion is etched and a protrusion amount of said sixth insulation film protruding from a surface opposite to the main surface of said semiconductor substrate toward the main surface of said semiconductor substrate in said first semiconductor film are each set to be equal to or smaller than one half of thickness of said first insulation film.

29. The manufacturing method for a semiconductor device according to claim 28, further comprising the steps of:

(k) depositing a seventh insulation film over the main surface of said semiconductor substrate after said step (j); and

(l) forming a fifth semiconductor film of the first conductivity type via said sixth and seventh insulation films over the side surface of said first opening portion by a dry-etching method.

30. The manufacturing method for a semiconductor device

according to claim 29, further comprising:

(m) removing, by the wet-etching method, said seventh insulation film exposed from said fifth semiconductor film in said first opening portion after the step (l), and forming a third opening portion from which a portion of said semiconductor film in said seventh insulation film is exposed; and

(n) forming a sixth semiconductor film contacting with said semiconductor film and insulated from said first semiconductor film after said step (m).

31. The manufacturing method for a semiconductor device according to claim 30,

wherein said first semiconductor region is a collector region of a bipolar transistor, said first semiconductor film is a base electrode of said bipolar transistor, and said sixth semiconductor film is an emitter electrode of said bipolar transistor.

32. The manufacturing method for a semiconductor device according to claim 28,

wherein said first and fifth insulation films are made from silicon oxide films and said third insulation film and sixth insulation film are made from silicon nitride films.

33. The manufacturing method for a semiconductor device according to claim 28,

wherein said semiconductor film is made from a material containing primarily a semiconductor of a kind different from said semiconductor substrate.

34. The manufacturing method for a semiconductor device according to claim 33,

wherein said semiconductor film is made from a material containing primarily silicon-germanium.

35. The manufacturing method for a semiconductor device according to claim 28,

wherein said semiconductor film is formed by joining a second semiconductor film growing from a surface exposed from said second opening portion of said first semiconductor film and a third semiconductor film growing from the main surface of said semiconductor substrate.

36. The manufacturing method for a semiconductor device according to claim 35,

wherein said second semiconductor film is a polycrystal and said third semiconductor film is a single crystal.

37. The manufacturing method for a semiconductor device according to claim 28,

wherein said fifth insulation film is made from an insulative material of the same kind as said first

insulation film.

38. A manufacturing method for a semiconductor device, comprising the steps of:

(a) forming a collector region of a first conductivity type of a bipolar transistor over a semiconductor substrate;

(b) depositing a first insulation film made from a silicon oxide film over a main surface of said semiconductor substrate;

(c) depositing a first semiconductor film that is a conductive film for forming said bipolar transistor over said first insulation film, the first semiconductor film being for forming a base electrode of a second conductivity type opposite to said first conductivity type;

(d) depositing a third insulation film made from a silicon nitride film over said first semiconductor film;

(e) depositing a fifth insulation film made from a silicon oxide film over said third insulation film;

(f) opening portions of said fifth insulation film and third insulation film by an etching method using a photoresist film as an etching mask;

(g) removing said photoresist film, thereafter removing said first semiconductor film exposed from the opening by using said fifth insulation film as an etching mask, and forming a first opening portion in said third and fifth insulation films and said first semiconductor film;

(h) forming a sixth insulation film made from a silicon nitride film over a side surface of said first opening portion;

(i) forming, in said first insulation film, a second opening portion, from which a surface opposite to the main surface of said semiconductor substrate and said collector region in said first semiconductor film are exposed, by selectively etching a portion of said first insulation film through said first opening portion using said third insulation film and sixth insulation film as etching masks; and

(j) forming, in said second opening portion, a second polycrystalline semiconductor film growing from a surface exposed from said second opening portion of said first semiconductor film and forming a link base of said bipolar transistor and a third single crystalline semiconductor film growing from the main surface of said semiconductor substrate and forming a true base region and emitter region of said bipolar transistor, by an epitaxial growth method so that they are joined to each other,

Wherein, during a processing for forming said first opening portion, an amount in which a portion of said first insulation film exposed from said first opening portion is exposed and a protrusion amount of said sixth insulation film protruded from a surface opposite to the main surface of said semiconductor substrate toward the main surface of said semiconductor substrate in said first semiconductor

film are equal to or smaller than one half of thickness of said first insulation film.

39. The manufacturing method for a semiconductor device according to claim 38, further comprising the steps of:

(k) depositing a seventh insulation film over the main surface of said semiconductor substrate after said step (j); and

(l) forming a fifth semiconductor film of the first conductivity type via said sixth insulation film and seventh insulation film over the side surface of said first opening portion by a dry-etching method.

40. The manufacturing method for a semiconductor device according to claim 39, further comprising the steps of:

(m) removing, in said first opening portion, said seventh insulation film exposed from said fifth semiconductor film by the wet-etching method after said step (l), and forming a third opening portion, from which a portion of said third semiconductor film is exposed, over said seventh insulation film; and

(n) forming a sixth semiconductor film for forming the emitter electrode, which contacts with said third semiconductor film and is insulated from said first semiconductor film after said step (m).

41. (New) The semiconductor device according to claim 2,
wherein a third insulation film is formed between said
second insulation film and said fourth semiconductor film
formed over a side surface of said first semiconductor film.

42. (New) The semiconductor device according to claim 9,
wherein a fifth insulation film is formed between said
fourth insulation film and said second electrode.

43. (New) The semiconductor device according to claim 18,
wherein an electrode to be an emitter region formed
over said single crystalline silicon-germanium film is
formed, and

an insulation film is further formed between the
silicon nitride film and said electrode formed over a side
surface of said first polycrystalline silicon film.

44. (New) The semiconductor device according to claim 19,
wherein a fifth insulation film is further formed
between said fourth insulation film and said emitter
electrode.